

## CLAIMS

1. A process for providing one or more protected copper elements on a surface of a workpiece, the process comprising the steps of:
  - applying a barrier layer to the workpiece;
  - 5       applying a seed layer on the barrier layer;
  - electroplating one or more copper elements on selected portions of the seed layer;
  - substantially removing the seed layer;
  - rendering at least a portion of a surface of the barrier layer unplatable;
  - 10       and
  - electroplating a protective layer onto surfaces of the one or more copper elements.
2. A process as claimed in claim 1 and further comprising the step of applying a  
15       dielectric layer over at least a portion of the one or more copper elements.
3. A process as claimed in claim 1 wherein the step of substantially removing  
the seed layer comprises the step of subjecting the seed layer to an electrolyte  
solution bath containing phosphoric acid while holding the seed layer at a  
20       positive electrical potential relative to an electrode that is immersed in the electrolyte solution bath.



4. A process as claimed in claim 1 and further comprising the steps of:

applying a dielectric layer to substantially cover the one or more  
copper elements;

5 removing a surface portion of the dielectric layer to expose one or  
more upper regions of the one or more copper elements.

5. A process as claimed in claim 1 wherein the step of rendering at least a  
portion of a surface of the barrier layer unplatable comprises the step of  
oxidizing exposed surfaces of the barrier layer material.

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6. A process as claimed in claim 1 wherein the step of electroplating one or  
more copper elements on selected portions of the seed layer comprises the  
steps of:

15 electroplating one or more copper lines on selected portions of the  
seed layer; and

electroplating one or more copper posts on selective portions of the  
copper lines.

7. A process as claimed in claim 1 wherein the step of rendering at least a  
20 portion of a surface of the barrier layer unplatable comprises the steps of :

concurrently oxidizing exposed surfaces of the barrier layer material  
and the one or more copper elements;



removing the resultant copper oxide from the one or more copper elements.

8. A process as claimed in claim 7 wherein the step of substantially removing  
5 the seed layer concurrently occurs during the step of removing resultant copper oxide layers from the one or more copper elements.
9. A process as claimed in claim 7 wherein the step of electroplating one or more copper elements on selected portions of the seed layer comprises the  
10 steps of:
  - electroplating one or more copper lines on selected portions of the seed layer; and
  - electroplating one or more copper posts on selective portions of the copper lines.
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10. A process as claimed in claim 1 and further comprising the step of removing the barrier layer, where it is not overlaid by a copper element, after electroplating the protective layer.
- 20 11. A process as claimed in claim 1 wherein the barrier layer and seed layer are applied in a first processing tool set.



12. A process as claimed in claim 11 wherein the electroplating steps  
and the rendering step are executed in a second processing tool set.
13. A process as claimed in claim 12 wherein the first processing tool set is a  
5 vacuum deposition tool set.
14. A process as claimed in claim 13 wherein the second processing tool set is a  
wet processing tool set.
- 10 15. A process as claimed in claim 11 wherein the first processing tool set is a  
vacuum deposition tool set.
16. A process as claimed in claim 1 wherein the barrier layer is comprised of  
tantalum.
- 15 17. A process as claimed in claim 1 wherein the seed layer is comprised of  
copper.
18. A process as claimed in claim 1 wherein the protective layer is comprised of  
20 a material selected from the group consisting of nickel, nickel alloys, and  
chromium.



19. A process as claimed in claim 1 wherein the step of electroplating one or more copper elements is comprised of the steps of:

applying a pattern mask layer over the seed layer whereby the selected portions of the seed layer are exposed; and

5 electroplating the one or more copper elements onto the seed layer through the exposed selected portions.

20. A process for providing one or more protected copper elements on a surface of a workpiece, the process comprising the steps of:

10 applying a conductive barrier layer to the workpiece;

electroplating one or more copper elements on selected portions of the conductive barrier layer;

rendering at least a portion of a surface of the conductive barrier layer unplatable; and

15 electroplating a protective layer onto surfaces of the one or more copper elements.

21. A process as claimed in claim 20 and further comprising the step of applying a dielectric layer over at least a portion of the one or more copper elements.

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22. A process as claimed in claim 20 and further comprising the steps of:



applying a dielectric layer to substantially cover the one or more copper elements;

removing a surface portion of the dielectric layer to expose one or more upper regions of the one or more copper elements.

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23. A process as claimed in claim 20 wherein the step of rendering at least a portion of a surface of the barrier layer unplatable comprises the step of oxidizing exposed surfaces of the barrier layer material.

10 24. A process as claimed in claim 20 wherein the step of electroplating one or more copper elements on selected portions of the conductive barrier layer comprises the steps of:

electroplating one or more copper lines on selected portions of the conductive barrier layer; and

15 electroplating one or more copper posts on selective portions of the copper lines.

25. A process as claimed in claim 20 wherein the step of rendering at least a portion of a surface of the barrier layer unplatable comprises the steps of :

20 concurrently oxidizing exposed surfaces of the barrier layer material and the one or more copper elements;



removing the resultant copper oxide from the one or more copper elements.

26. A process as claimed in claim 20 and further comprising the step of removing  
5 the barrier layer, where it is not overlaid by a copper element, after  
electroplating the protective layer.
27. A process as claimed in claim 20 wherein the barrier layer is applied in a first  
processing tool set.
- 10 28. A process as claimed in claim 27 wherein the wherein the electroplating steps  
and the rendering step are executed in a second processing tool set.
29. A process as claimed in claim 28 wherein the first processing tool set is a  
15 vacuum deposition tool set.
30. A process as claimed in claim 29 wherein the second processing tool set is a  
wet processing tool set.
- 20 31. A process as claimed in claim 27 wherein the first processing tool set is a  
vacuum deposition tool set.



32. A process as claimed in claim 20 wherein the barrier layer is comprised of titanium nitride.

33. A process as claimed in claim 20 wherein the protective layer is comprised of  
5 a material selected from the group consisting of nickel, nickel alloys, and chromium.

34. A process as claimed in claim 20 wherein the barrier layer comprises titanium  
nitride overlying tantalum nitride and wherein the protective layer is  
10 comprised of a material selected from the group consisting of nickel, nickel alloys, and chromium.

35. A process as claimed in claim 20 wherein the step of electroplating one or  
15 more copper elements is comprised of the steps of:

applying a pattern mask layer over the barrier layer whereby the  
selected portions of the conductive barrier layer are exposed; and

electroplating the one or more copper elements onto the conductive  
barrier layer through the exposed selected portions.



36. A process for providing one or more copper metallization layers on a surface of a semiconductor workpiece, the process comprising the steps of:

applying a barrier layer to the semiconductor workpiece;

applying a seed layer on the barrier layer;

5       electroplating one or more copper interconnect lines on selected portions of the seed layer;

electroplating one or more copper posts on selected portions of the copper interconnect lines;

substantially removing the seed layer;

10       concurrently oxidizing exposed surfaces of the one or more copper interconnect lines, exposed surfaces of the one or more copper posts, and exposed surfaces of the barrier layer;

removing resultant copper oxide layers from the one or more copper interconnect lines and the one or more copper posts while leaving the oxidized barrier layer surfaces substantially intact so as to leave the barrier layer surfaces unplatable;

15       electroplating a protective layer onto exposed surfaces of the one or more copper interconnect lines.

20       37. A process as claimed in claim 36 and further comprising the step of applying a dielectric layer over at least a portion of the one or more copper elements.



38. A process as claimed in claim 36 and further comprising the steps of:

applying a dielectric layer to substantially cover the one or more  
copper interconnect lines and the one or more copper posts;

5 removing a surface portion of the dielectric layer to expose upper  
regions of the one or more copper posts.

39. A process as claimed in claim 36 and further comprising the step of removing  
the barrier layer, where it is not overlaid by an interconnect line, after  
electroplating the protective layer.

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40. A process as claimed in claim 36 wherein the barrier layer and seed layer are  
applied in a first processing tool set.

41. A process as claimed in claim 40 wherein the wherein the electroplating steps  
15 and the oxidizing step are executed in a second processing tool set.

42. A process as claimed in claim 41 wherein the first processing tool set is a  
vacuum deposition tool set.

20 43. A process as claimed in claim 42 wherein the second processing tool set is a  
wet processing tool set.



44. A process as claimed in claim 40 wherein the first processing tool set is a vacuum deposition tool set.

45. A process as claimed in claim 36 wherein the step of electroplating one or  
5 more copper interconnect lines is comprised of the steps of:  
applying a pattern mask layer over the seed layer whereby the selected  
portions of the seed layer are exposed; and  
electroplating the one or more copper interconnect lines onto the seed  
layer through the exposed selected portions.

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46. A process as claimed in claim 45 wherein the step of electroplating one or  
more copper posts is comprised of the steps of:

applying a pattern mask layer over the seed layer and the one or more  
interconnect lines whereby selected upper portions of the copper  
15 interconnect lines are exposed; and  
electroplating the one or more copper posts onto the copper  
interconnects lines through the exposed portions.

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47. A process as claimed in claim 36 wherein the barrier layer is comprised of  
tantalum.



48. A process as claimed in claim 36 wherein the seed layer is comprised of copper.
49. A process as claimed in claim 36 wherein the protective layer is comprised of  
5 a material selected from the group consisting of nickel, nickel alloys, and chromium.
50. A process as claimed in claim 36 wherein the step of substantially removing  
the seed layer concurrently occurs during the step of removing resultant  
10 copper oxide layers from the one or more copper interconnect lines and the one or more copper posts .
51. A process as claimed in claim 36 wherein the step of substantially removing  
the seed layer comprises the step of subjecting the seed layer to an electrolyte  
15 solution bath containing phosphoric acid while holding the seed layer at a positive electrical potential relative to an electrode that is immersed in the electrolyte solution bath.